Introduction to Nuclear Safeguards Training

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LLNL-INL Safeguards Training Program

June 11, 2009

Quick Acknowledgements

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- Special thanks to our presenters:
- Mary Adamic, INL
- Robert Bean, INL
- Adam Bernstein, LLNL
- David Chichester, INL
- Bill Domke, LLNL
- Arden Dougan, LLNL
- Casey Durst, DNE-INL
- Jonathan Essner, LLNL
- John Luke, LLNL
- Richard Metcalf, INL
- Mark Schanfein, INL
- Ross Williams, LLNL

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Overview

- Introduction to the Training
  - Purpose
  - Lecturers
  - Topics to be covered
- Introduction to Nuclear Safeguards
  - Definitions
  - The International Atomic Energy Agency
  - Introduction to Safeguards Methods
- Review

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LLNL-INL Safeguards Training

- Series of lectures designed to bring the incoming professional or student to a “baseline” of understanding
- Presented by professionals who are specialized in the fields from Lawrence Livermore National Laboratory and Idaho National Laboratory
- Designed to become a recurrent training program offered each summer for the intern communities in the Department of Energy (DOE) complex

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Purpose of LLNL-INL-STP

- Students must be able to understand the major issues in nuclear safeguards
  - Specific vernacular of safeguards
  - Legal basis for nuclear safeguards and security
  - Introduction to the IAEA
  - Common techniques for safeguards
  - Emerging techniques for safeguards
  - Historical and modern challenges in safeguards
  - Interaction of safeguards with other methods of protecting special nuclear material

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Lecturers of the Training

- INL: Robert Bean, Mary Adamic, Mark Schanfein, Casey Durst, David Chichester, Richard Metcalf
- LLNL: Adam Bernstein, Bill Domke, Arden Dougan, Jonathan Essner, John Luke, Ross Williams

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Topic list of LLNL-INL-STP

• Thursday, June 11	Introduction to Nuclear Safeguards
• Tuesday, June 16	The Nuclear Fuel Cycle
• Thursday, June 18	International Safeguards Systems, Science & Technical Challenges
• Tuesday, June 23	A Day in the Life of an Inspector
• Thursday, June 25	Material Control and Accounting
• Tuesday, June 30	Destructive Analysis Methods
• Thursday, July 2	Nondestructive Analysis Methods

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Topic list of LLNL-INL-STP

- Tuesday, July 7 — Passive & Active Interrogation
- Thursday, July 9 — Environmental Sampling
- Week of July 13 — INMM
- Tuesday, July 21 — Advanced Safeguards Approaches
- Thursday, July 23 — Statistics and Safeguards & Basic Process Monitoring
- Tuesday, July 28 — The Story of Proliferation
- Tuesday, August 4 — Open-Source Information: Collection and Analysis

Definitions and Terminology of Safeguards

- Nuclear Safeguards: measures to verify that civil nuclear facilities are not being misused to pursue weapons and associated materials are properly accounted for and are not diverted to undeclared uses
  - This is the operating definition that will be used by the majority of lecturers of this group.
  - Domestic safeguards (in-country, specifically in-USA) refers to traditional safeguards (above) as well as physical security measures.
  - Note that safeguards are a method of verification: safeguards are not designed to prevent the diversion of material but rather to identify that it occurred and therefore prevent by deterring.

Definitions and Terminology, cont.

- Physical security: measures to prevent the theft of nuclear material
  - Sometimes called “Guards, Gates, and Guns”
  - A country cannot “steal” from itself. Physical security prevents insiders and external threats from stealing material from a facility.

- International Safeguards: Safeguards as described previously, administered by the International Atomic Energy Agency

Definitions and Terminology, cont.

Material	SQ
Direct use nuclear material	
Pu[a]	8 kg Pu
^{233}U	8 kg ^{233}U
HEU ($^{235}U \geq 20\%$)	25 kg ^{235}U
Indirect use nuclear material	
U ($^{235}U < 20\%$)[b]	75 kg ^{235}U (or 10 t natural U or 20 t depleted U)
Th	20 t Th

[a] For Pu containing less than 80% ^{238}Pu.
[b] Including low enriched, natural and depleted uranium.

- **Significant Quantity: The approximate quantity of nuclear material in respect of which, taking into account any conversion process involved, the possibility of manufacturing a nuclear explosive device cannot be excluded.**
- **Includes machining assumptions not discussed here**
  - **The basic "unit" for international (IAEA) safeguards.**

Information about SQs can be found on IAEA.org and the IAEA safeguards glossary, as well as their existing technical documents.

Definitions and Terminology, cont.

- Special Nuclear Material: nuclear material which can be made into a nuclear explosive device
  - In common nomenclature: Highly Enriched Uranium and Plutonium

- Highly Enriched Uranium: Uranium with 20% or greater U-235

- Timeliness Goal: Amount of time that the International Atomic Energy Agency has to detect a diversion of material
  - Related to the “latency” between diversion and weaponization of the material
  - More on this later

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Definitions and Terminology, cont.

- The Treaty on the Non-Proliferation of Nuclear Weapons (NPT): the legal basis for international safeguards, obligating signatories to the international safeguards regime
  - The NPT entered-into-force on March 5, 1970
  - Nuclear-Weapon State (NWS), identified as states which had manufactured and exploded a nuclear explosive device prior to January 1, 1967, are required not to assist or encourage Non-Nuclear-Weapon States, in any way, to acquire a nuclear explosive device(s)
  - Non-Nuclear-Weapon State (NNWS) are required
    - Not to manufacture or otherwise seek to acquire a nuclear explosive device(s)
    - To accept safeguards, under an agreement with the IAEA, on all nuclear material in <u>all</u> peaceful activities

Definitions and Terminology

- Information Circular #153 (INFCIRC153): The basic safeguards framework that is in common use with all NPT signatories.
- Additional Protocol: An addition to the basic safeguards suite which gives greatly expanded powers to the IAEA.
- State System of Accounting and Control (SSAC): the state's system of determining where all of their nuclear material is at the time of a declaration.
- Material Unaccounted For (MUF): Material that is not accounted for by the current measurements. This does not mean it is diverted, as it could be stuck in pipes or otherwise still in the facility.
- Declaration: A formal reporting of material or operations in a facility to the International Atomic Energy Agency.

The International Atomic Energy Agency

- The primary safeguards system in use today is the International Safeguards System of the International Atomic Energy Agency (IAEA)
  - other safeguard systems exist such as the U.S. Nuclear Regulatory Commission (NRC) Safeguards and Security System and Euratom Safeguards, which are often more rigorous
- While these other safeguard systems are important, due to time constraints we will focus only on the IAEA (international) safeguards system

The International Atomic Energy Agency

- Created in 1957 by the United Nations General Assembly
- 138 Member States (MS)
- 2247 Professionals and Support Staff
- 274 M.US$ → Regular Budget 2006
- 77.5 M.US$ → Technical Cooperation Fund
- About 51 M.US$ →Extra budgetary
- Reports to : United Nations General Assembly (annually), United Nations Security Council (when appropriate), United Nations Economic & Social Council

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The IAEA Board of Governors

The International Atomic Energy Agency

- Three primary missions:
  - Promotion of peaceful uses of nuclear energy
  - Develop nuclear safety and security standards, promoting high levels in both as well as the protection of people and the environment.
  - Application of Safeguards
    - The IAEA verifies correctness of a state's declaration to provide assurance on the non-diversion of <u>declared</u> nuclear material;
    - Verifies completeness of a state's declarations to provide credible assurance on the absence of undeclared nuclear material and activities.

Safeguards Agreements

- An agreement for the application of safeguards concluded between the IAEA and a State or a group of States
  - in certain cases, with a regional or bilateral inspectorate, such as Euratom and ABACC (South American, Argentina-Brazil)
  - agreement is concluded either because
    - of the requirements of a project and supply agreement
    - to satisfy the relevant requirements of bilateral or multilateral arrangements
    - at the request of a State to any of that State's nuclear activities
  - Each State's agreement is different.
    - But there are some commonalities, based on type

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Non-Compliance

- Violation by a State of its safeguards agreement with the IAEA. For example:
  - the diversion of nuclear material from declared nuclear activities
  - the failure to declare nuclear material required to be placed under safeguards
  - under an additional protocol, the failure to declare nuclear material, nuclear activities, or nuclear related activities required to be declared
  - violation of the agreed recording and reporting system
  - obstruction of the activities of IAEA inspectors
  - interference with the operation of safeguards equipment
- if non-compliance, the IAEA Director General shall report to the IAEA Board of Governors
  - which would call upon the recipient State to remedy any non-compliance
  - There are historical, and current, cases where the State has ejected IAEA inspectors.

International Atomic Energy Agency

- Everyone presenting in this series helps support the IAEA through our research.

- Ensuring that all countries around the world are not diverting material or misusing facilities or working with hidden facilities on a constrained budget is not a trivial task
  - Also, that diversion can be, in some cases, less than 0.1% of a facility's material handling,
  - And States can actively block your inspections, or bulldoze sites before you can inspect them,
  - With a requirement for almost total transparency to the international community .

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Safeguards Methods

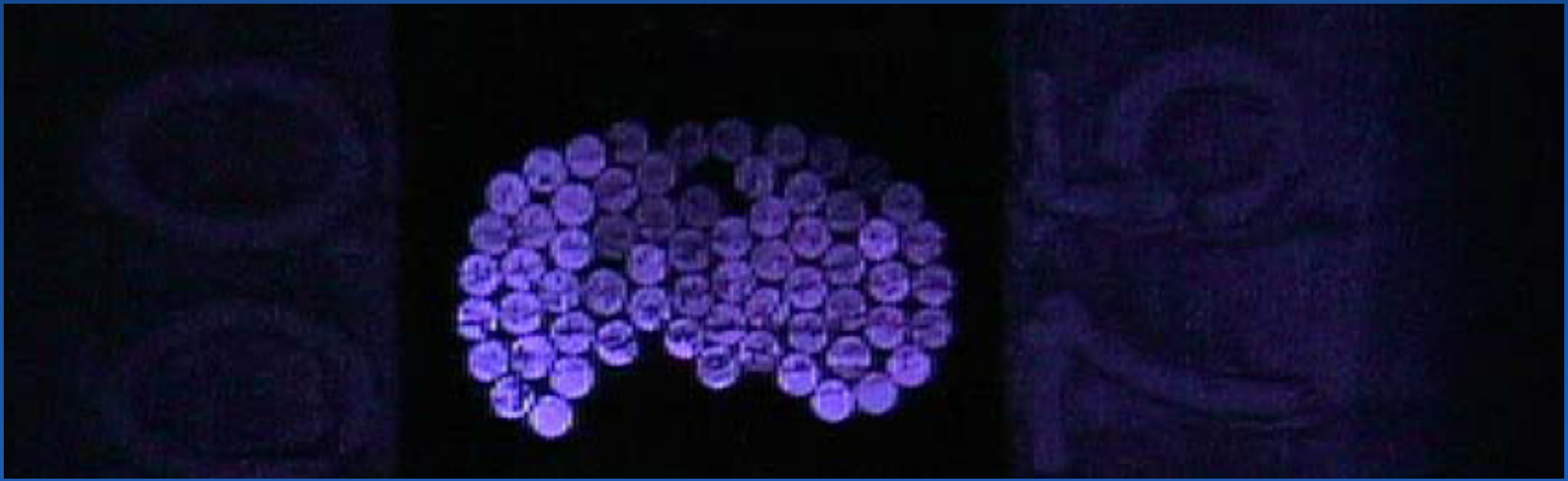
- Safeguards are executed in several ways
  - Before a facility is built, information about the facility is given to the IAEA on a Design Information Questionnaire
    - The DIQ is part of a larger group of measures in Design Information Verification to ensure facilities are built and operated as designed
  - The DIQ is used to help build the safeguards approach, which is negotiated and added to the safeguards agreement

Safeguards Methods

- The safeguards approach can include several different types of IAEA systems
- These systems fall into several typical categories
  - Tamper Indicating Devices (Seals)
  - Containment and Surveillance (Cameras)
  - Radiation Monitors (Nondestructive Analysis)
    - Can be passive (receiving) or active (emitting)
  - Very small nuclear materials sampling (Destructive Analysis)
  - Swipe samples from the environment
  - Process Monitoring systems to watch the operating parameters of a chemical process
  - Advanced Systems

Tamper Indicating Devices (TIDs)

- TIDS are seals that the agency uses on its cabinets as well as storage casks and other areas for which little to no movement is expected
- These can be fiber optic, metal, plastic, and come in varied shapes, sizes, and types



Containment and Surveillance (C/S)

- Containment and surveillance is the use of observations (often qualitative) as part of the safeguards suite
- The Agency relies heavily on containment and surveillance in many modern facilities as part of the safeguards approach
- The C/S systems are quite robust, but automated analysis remains a challenge because of data overload

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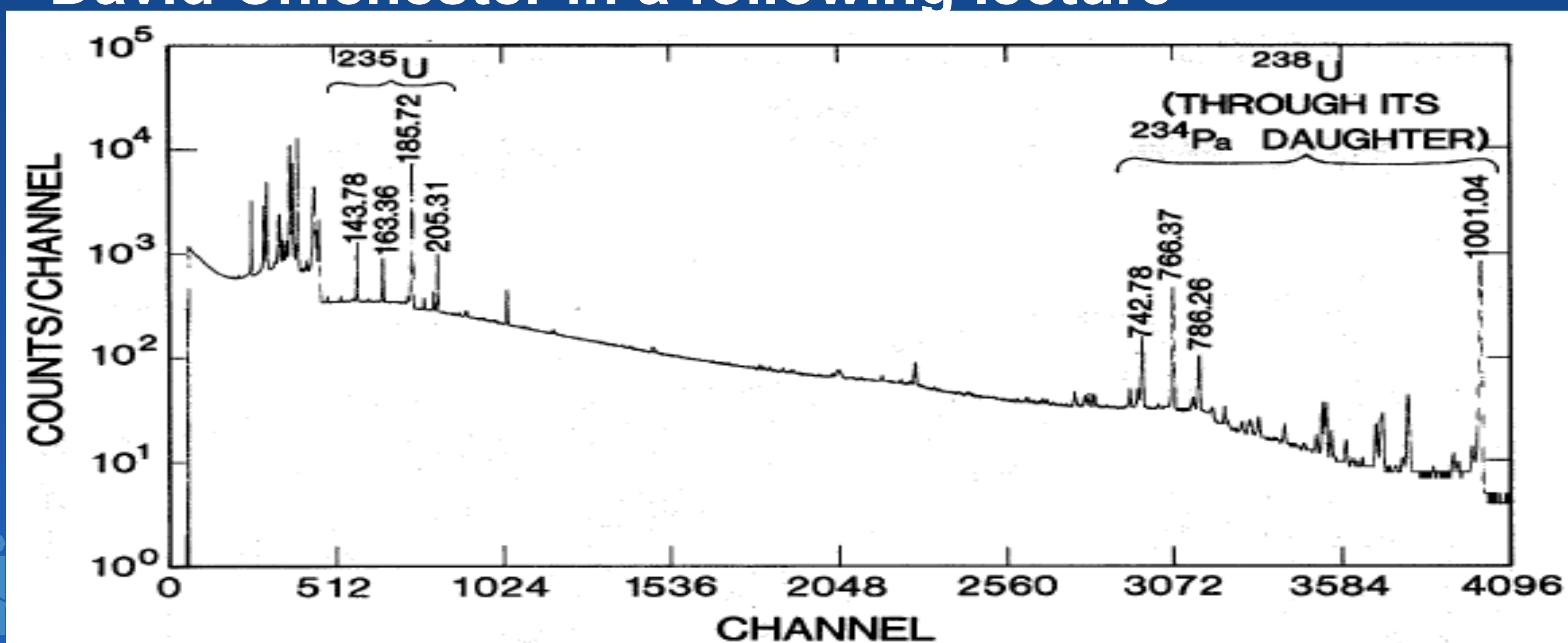
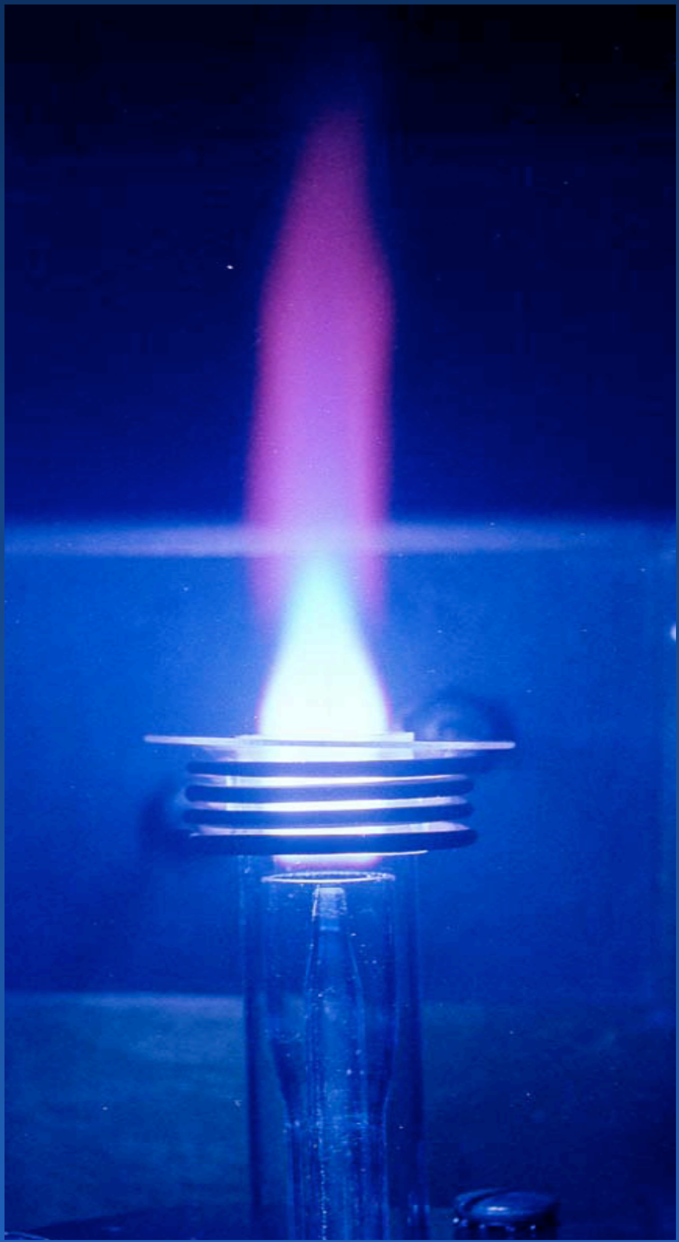
Nondestructive Analysis

- Either simply listens, or evokes an echo from material to garner signals without destroying any amount of the material or requiring a sample
- These systems will be explained in more detail by David Chichester in a following lecture



Destructive Analysis

- Requires a small sample pulled from the item or process that you are measuring
- Typically more accurate, but slower, than NDA
- DA is the "workhorse" of most safeguards approaches
- Mary Adamic will present a lecture on this in more detail



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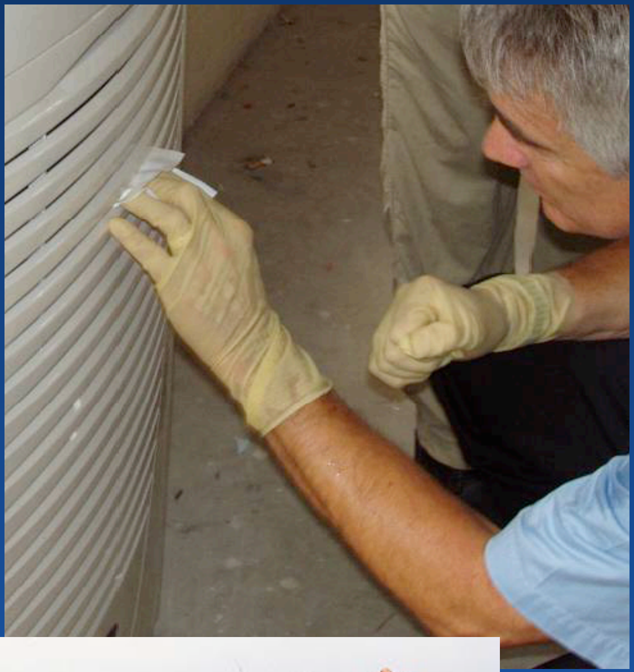
Environmental Sampling

- Nuclear material processes do release very trace amounts of materials into the environment
- Analysis of environmental samples can reveal the presence of undeclared activity
- Ross Williams will lecture on this topic on a later date



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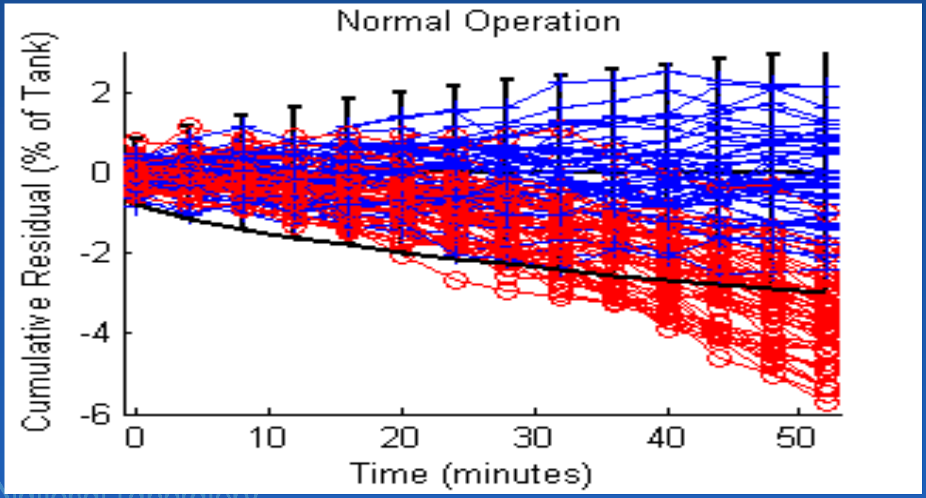
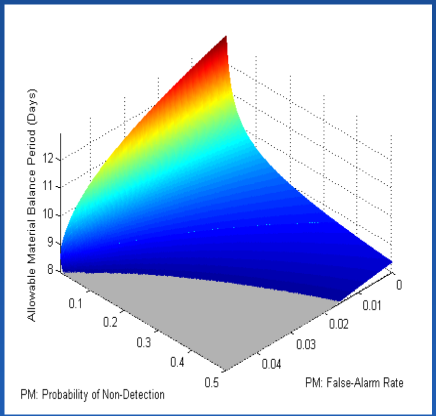
Process Monitoring

- By watching chemical process information, as well as online NDA, diversions can be detected
- Watching the process helps give a first pass as to anomalies that may be occurring, and the recorded data can lead inspectors to a potential problem
- I will lecture about this topic at a later date





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In Review

- International Safeguards exists to prevent the use of nuclear materials for weapons purposes
- It is given legal authority by the Nonproliferation Treaty (NPT)
- The International Atomic Energy Agency is the international inspectorate, which uses several methods to ensure that
  – Facilities are not diverting material
  – There are no other facilities than those declared

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Next Time

- Adam Bernstein will present an overview of the nuclear fuel cycle